Livestock-Handling Injuries in Agriculture: An Analysis of Colorado Workers' Compensation Data

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Background *Previous studies have reported that livestock-handling injuries are among the most severe of agricultural injuries. This study identifies the costs, characteristics, and contributing factors associated with livestock-handling injuries among Colorado dairy farmers, cattle/livestock raisers, and cattle dealers.*
Methods *A 10-year (1997–2006) history of Colorado's workers' compensation claims data was used for analysis. Descriptive analyses of livestock-handling injury claims were performed. Claim cost analysis was also conducted. The agent–host–environment epidemiological model was used to analyze injury event descriptions.*
Results *A total of 1,114 livestock-handling claims were analyzed. Claims associated with milking parlor tasks represented nearly 50% of injuries among dairy workers. Claims associated with riding horseback, sorting/penning cattle, and livestock-handling equipment represented high proportions of livestock-handling injuries among cattle/livestock raisers and cattle dealers. Claims associated with livestock-handling represented the highest percentage of high-cost and high-severity injuries in all three sectors.*
Conclusions *Livestock-handling injuries are a significant problem, more costly, and result in more time off work than other causes of agricultural injuries. There is a strong and compelling need to develop cost-effective interventions to reduce the number of livestock-handling injuries in agriculture.* Am. J. Ind. Med. 52:391–407, 2009.

KEY WORDS: occupational injury; agriculture; livestock; workers' compensation

INTRODUCTION

Farming ranks among the highest of United States (US) industries for work-related fatal and non-fatal injuries. The lack of information regarding agricultural injuries has been recognized as an obstacle in the development of effective injury prevention measures [Zhou and Roseman, 1994]. Within the past two decades increased emphasis has been placed on quantifying and limiting farm-work injury hazards. Studies have consistently reported that farm machinery, livestock, and falls are major contributors to agricultural injuries [Brison and Pickett, 1992; Pratt et al., 1992; Zhou and Roseman, 1994; Nordstrom et al., 1995].

Because of the increasing mechanization of farming over the past half century, and the high fatality rate associated

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with injuries due to machinery and tractors [McFarland, 1968; Simpson, 1984; McKnight and Hetzel, 1985; Hopkins, 1989; Etherton et al., 1991; Lee et al., 1996; Bernhart and Langley, 1999; Carlson et al., 2005; Cole et al., 2006], most studies of agricultural injuries have focused on issues related to interactions with machinery or tractors. Animal-related injuries are also an important occupational hazard in agriculture. Animals may bite, kick, scratch, trample, crush, gore, buck or throw, or drag the livestock-handler [Langley, 1999]. Studies demonstrated non-fatal injury rates are elevated on operations with livestock, especially beef and dairy cattle [Brison and Pickett, 1992; Pratt et al., 1992; Zhou and Roseman, 1994; Nordstrom et al., 1995]. Researchers have reported between 12% and 33% of injuries on the farm are caused by animals [Cleary et al., 1961; Cogbill et al., 1985; Hoskin et al., 1988; Myers, 1990; Brison and Pickett, 1992; Pratt et al., 1992; Zhou and Roseman, 1994; Layde et al., 1995; Nordstrom et al., 1995; Pickett et al., 1995; Gerberich et al., 1998; Lewis et al., 1998; Sprince et al., 2003] and livestock-related injuries account for the highest rate of lost work days [Thu et al., 1997].

Researchers described the difficulties in quantifying the magnitude of farm-work injuries specifically associated with livestock-handling [May, 1990; Ehlers et al., 1993]. Few studies specifically addressed injuries related to livestock-handling [Boyle et al., 1997; VonEssen and Donham, 1999; Hendricks and Adekoya, 2001; Sprince et al., 2003]. Because of the limited research addressing work injuries associated with livestock-handling, little is known of the risk factors that might lead to the development of safety interventions [Layde et al., 1996].

Previous studies analyzed workers' compensation (WC) data to investigate agricultural injuries and illnesses among hired farm workers [Demers and Rosenstock, 1991; Heyer et al., 1992; Belville et al., 1993; Cooper and Rothstein, 1995; Villarejo, 1998; Douphrate et al., 2006; Hofmann et al., 2006]. The present study is the first to utilize WC claims to specifically investigate livestock-handling injuries. The purpose of this study was to determine the costs, consequences, and contributing factors associated with WC livestock-handling injury claims among dairy farm, cattle/livestock, and cattle dealer workers in Colorado.

METHODS

Data Source

Pinnacol Assurance, Colorado's largest WC insurer, provided the data used in this study. With more than 90 years of providing WC coverage in Colorado and a market share of more than 50%, Pinnacol Assurance is the largest WC provider in the state. Pinnacol Assurance insures approximately 60,000 Colorado businesses and their employees [Pinnacol Assurance, 2007].

Colorado Workers' Compensation

The Colorado Division of Workers' Compensation is the state agency responsible for administering and enforcing WC laws. Colorado statute allows employers to finance WC risk through commercial insurance, self-insurance, and insurance enabled by statute. Commercial insurance for WC may be purchased from over 300 carriers authorized to conduct such business in Colorado. Colorado WC statute allows for employers, meeting rigid financial and loss control standards, to self-insure (self-fund). Pinnacol Assurance is a quasi-public insurance company enabled by Colorado statute.

Colorado statute requires any business with one or more employees to maintain a policy of WC insurance or obtain a self-insurance permit. Business owners, partners, and corporate officers may elect to reject coverage. According to the Colorado Workers' Compensation Act, injured workers must make a written report to the employer within 4 days of the injury event. Within the next 10 days the employer must submit a First Report of Injury to the WC provider. The WC provider then has 20 days from the date of receipt of First Report of Injury to admit or deny the claim [Colorado Department of Labor and Employment, 2007].

Workers' compensation benefits include payment for medical expenses, wage-replacement, permanent impairment or disfigurement, and death benefits. Medical benefits include payment for all expenses associated with physician visits, hospital treatments, rehabilitation, diagnostic testing, and prescription medications. Wage-replacement benefits (indemnity) include payment for lost wages, up to two-thirds of the injured worker's normal earnings. An injured worker is eligible for indemnity benefits after three lost days of work due to injury.

Data Sample

A 10-year claim history of injuries occurring from the period January 1, 1997 through December 31, 2006 was analyzed. All 12-month policies were included in the dataset, including those that did and did not have reported injuries. All injury claims were closed. Claims data represented Colorado dairy farm, cattle dealer, and cattle/livestock raising occupations.

Pinnacol Assurance provides coverage for more than 50% of Colorado agriculture operations that are required by law to maintain a policy of WC coverage. Historically, an accurate estimation of agriculture worker populations has been difficult to determine. According to the 2002 Census of Agriculture [NASS, 2002], there were 31,369 farms in Colorado. A total of 7,747 farms reported 46,005 farming jobs. Crop farms employed 27,546 workers and livestock operations (excluding poultry and egg production, animal aquaculture, and other animal production) employed 14,299 workers. Colorado livestock operations accounted for about

$153 million of the state total of direct–hire farm labor expense, representing 42% of the total for all of the state's agriculture operations [NASS, 2002]. A more detailed analysis of employment patterns revealed a marked difference between crop and livestock operations. Reports by crop farms indicate nearly 70% of workers were employed less than 150 days reflecting a seasonal employment pattern. In contrast, reports by livestock operations indicate 52% of workers were employed less than 150 days [NASS, 2002]. According to the Bureau of Labor Statistics Quarterly Census of Employment and Wages for Colorado, monthly employment for animal production operations (NAICS 112) varied only slightly from 2001 through 2006, ranging from 5,300 to 5,800 workers in all months [US Department of Labor, 2008]

The claim dataset included details concerning each injury: the nature of injury; body part(s) affected; source of injury; cause of injury; demographic characteristics of the employee (age, gender, work experience); policy holder payroll; risk classification code; medical expense; indemnity paid (if any); days of paid indemnity; and a narrative description of the injury event. Claims data were taken from the First Report of Injury for each injury claim. The First Report of Injury may be completed by the injured or by the foreman, supervisor, or business owner.

Data Collection

As in all other states, Pinnacol Assurance uses a standardized set of empirically derived Risk Classification Codes (class codes) to assign occupational sectors. Four-digit class codes are outlined in the National Council on Compensation Insurance (NCCI) *Scopes Manual* [National Council on Compensation Insurance, 2003]. Class codes are used by the WC insurance industry to classify occupations and their job responsibilities and assign occupational risk. For this study, Pinnacol Assurance provided injury claim data for dairy farms (NCCI 0036), cattle/livestock raising (NCCI 0083), and cattle dealers (NCCI 8288). The injury claims data were extracted from an Oracle [Oracle Corporation, 2002] relational database using Hyperion Explorer 6.6.4 [Hyperion Solutions Corporation, 2004]. Claims data were electronically transmitted to the primary investigator who was provided security password access. Strict confidentiality of all claims was enforced throughout the investigation, and personal identifiers were removed prior to electronic transmission of data. The intuitional review board at Colorado State University reviewed and approved the study procedures.

Case Definition

A lack of uniform definitions and classification schemes has hindered farm injury research. Some but not all farms are places of residence as well as places of business [Murphy et al., 1990]. The 2002 Census of Agriculture reported 81% of Colorado farm operators reside on their farm [NASS, 2002]. As an industry, agriculture includes farm production work and agricultural services. Workers, owner/operators, managers, and a host of other codes comprise the agricultural occupations. Because of overlapping classifications, the determination of an ''at work'' injury is difficult in agriculture. Since WC data were used in this study, work-relatedness of each injury claim was assumed. This includes injury claims of farm resident workers. An injury claim for an off-the-job injury for a farm resident worker is valid only if the terms of employment explicitly require the worker to reside on the farm. If there is no such stipulation, an off-the-job injury does not qualify for workers compensation.

Agricultural work was defined in the study as agricultural production, including crops, livestock, and animal specialties, and agricultural services. A livestock-handling injury claim was defined as any unintentional work-related injury resulting from the performance of any livestock-handling related job task. Only claims accepted by the WC provider were analyzed. Injury severity was based on data provided for each injury claim; therefore no minimum level of injury severity was required for inclusion in the analysis.

Identification of Livestock-Handling Injuries

There was no single injury code in the dataset that would encompass all potential livestock-handling injury events; therefore, these claims were identified using a combination of search strategies. First, the injury source data field was queried for all claim sources classified as ''animals'' and ''animals, insects, birds, or reptiles.'' Second, narrative text fields containing the circumstances of the injury (narrative description) were searched to identify potential livestock-handling injuries. Words used to describe livestock-handling activities were used as index terms for livestock-handling claim identification. Livestock-handling injuries were identified by locating the index terms ''animal,'' ''buffalo,'' ''calf,'' ''cattle,'' ''chute,'' ''cow,'' ''fence.'' ''gate,'' ''goat,'' ''herd,'' ''horse,'' ''herding,'' ''hog,'' ''pig,'' ''pen,'' ''penning,'' ''swine,'' and ''trailer.'' After locating claims using this list of words, each claim was examined to determine if the injury was related to livestock handling.

Data Analysis

Incidence rates were estimated using employment payroll data of the claimant's employer (policy holder). Using information on policy payroll per calendar year, time at risk (expressed as hours worked by operation) was estimated using Colorado annual average wage rates as reported by the US Department of Agriculture [NASS, 2007].

Conversion of payroll data to hours worked was based on the same methodologies as described by Glazner et al. [1998] and Lowery et al. [1998]. Aggregate time at risk was based on hours worked, summed from 1997 to 2006 for each operation. Total work hours were estimated by the following formula:

$$\text{Estimated total work hours} = \frac{\text{Total sector payroll}}{\text{Average hourly wage}} \quad (1)$$

Overall and livestock-handling claim incidence rates were calculated per 200,000 hr (equivalent to injuries per 100 workers per year) worked according to the following formula:

$$\text{Injury claim rate} = \left(\frac{\text{Category claim count}}{\text{Estimated total work hours}}\right) \times 200,000 \text{ work hours} \quad (2)$$

Injury claim rate confidence intervals were constructed as described by Haenszel et al. [1962] assuming a Poisson distribution.

Proportionate injury ratios (PIRs) were estimated to compare the proportion of livestock-handling injuries by risk classification code, operation size, age, gender, and experience. Similar to proportionate mortality ratio analysis, proportionate injury ratio analysis is commonly used to identify differences among groups when information regarding the underlying population is limited or not available [Lipscomb and Li, 2001]. Proportionate injury ratios and associated 95% confidence intervals were calculated using methods for calculating proportionate mortality ratios [Lipscomb and Li, 2001; Checkoway et al., 2004; Lombardi et al., 2005; Smith et al., 2006]. Statistical significance of the observed-to-expected ratios was assessed using χ^2 tests. The PIR was calculated by comparing the observed proportions of claims of one group of interest to that which would be expected if they were to have the same injury experience as a reference group of interest. Since proportions must equal 100%, an increase in one injury category will be offset by a decrease in another category.

Descriptive analyses of livestock-handling injury characteristics included the frequency of claims by injury nature, body part, and month of injury. To compare injuries across occupation, gender, age, and experience two categories of medical costs and disability duration were used. High cost injuries were defined as those resulting in $5,000 or more in direct medical costs and serious disability was defined as those injuries resulting in 28 or more days of disability [Smith et al., 2006]. All data analyses were performed using SAS PC software version 9.1.2.

Narrative descriptions of events were analyzed to determine contributing factors of livestock-handling injuries. These factors were classified using the agent–host–environment epidemiological model [Gordis, 2004]. According to this tripartite model, an injury is the product of an interaction of the *host* (person injured), an *agent* that injures, and the *environment* that promotes the exposure. A *vector* or *vehicle* transmits the energy from the agent to the host. Agents of injury have been identified as the various forms of energy: mechanical, thermal, chemical, electrical, ionizing radiation, or too little energy in the case of asphyxiation [Gibson, 1961]. To the best of our knowledge, this is the first study to apply this model to investigate livestock-handling injuries using WC data.

RESULTS

A total of 4,421 injury claims, representing 8,493 separate 12-month policies were included in this study (Table I). The dataset included 605 dairy farm policies, 7,083 cattle/livestock raiser policies, and 805 cattle dealer policies in the 10-year sample period. Authors were not provided policy employment numbers making the estimation of coverage of state livestock workers represented in the dataset difficult. The 2002 Census of Agriculture was referenced to

TABLE I. Summary of Employment and Injury Data for Dairy Farms, Cattle/Livestock Raisers, and Cattle Dealers, 1997–2006 Combined

	Dairy farms	Cattle/livestock raisers	Cattle dealers
Total policies	605	7,083	805
Total policies with $\leq$10 FTEs	341	6,628	543
Total policies with $>$10 FTEs	264	455	262
Total annual FTEs per policy (average for 1995–2006)	17.5	3.8	15.3
Total policies reporting injury claims	285	1,212	346
Total policies reporting livestock-handling claims	92	266	103
Total injury claims	988	2,168	1,265
Average annual injury claim incidence rate (95% CI)[a]	9.39 (8.82–10.00)	9.18 (8.80–9.58)	11.45 (10.83–12.10)
Total livestock-handling claims	307	471	336
Average annual livestock-handling claim rate (95% CI)[a]	2.92 (2.61–3.27)	2.00 (1.82–2.19)	3.04 (2.73–3.39)

[a]Injury claim rate = number of claims per 100 employees (or 200,000 work hours).

provide an indication of the number of farms represented in the three class codes. According to the 2002 Census of Agriculture, 130 dairy farm, 306 cattle feedlot, and 2,386 beef cattle farm operators reported hired labor expense [NASS, 2002]. The injury claim dataset included 67 dairy farm, 149 cattle dealer, and 730 cattle raising operation distinct policies for the same year. Agriculture operations in the state could have chosen other insurance providers for their WC coverage, or elected to self-insure their injury claim expenses. For example, in 2002 two of the largest operators of cattle feedlots in Colorado, together representing five of the largest feedlots in the state were self-insured. In 2002, no dairy or cattle/livestock operations were self-insured [Colorado Department of Labor and Employment, 2008].

The number of claims included 988 from dairy farms, 2,168 from cattle/livestock raisers, and 1,265 from cattle dealers. A total of 1,114 livestock-handling claims were identified. Injury claim incident rates are also presented in Table I. Average annual claim incidence rates (injury claims per 100 workers) were highest for cattle dealers (10.3), followed by dairy farms (9.4) and cattle/livestock raisers (8.4). Livestock-handling claim rates were highest among all injury causes in all three sectors (2.9 for dairy farms, 2.7 for cattle dealers, and 1.8 for cattle/livestock raisers).

Livestock-Handling Injury Characteristics

Livestock-handling injury claims were responsible for the highest percentage of claims in all sectors (Table II). Of total claims among dairy farms, 31.1% were caused by livestock. Livestock was responsible for 21.7% and 26.6% of claims among cattle/livestock raisers and cattle dealers, respectively. Falls or slips and strains represented the second and third highest proportion of injury causes among all three sectors. Nature of injury and body part injured associated with livestock-handling injuries is presented in Table III. Contusions and injuries to the wrist, hand, and fingers represented the highest percentages in all three sectors.

TABLE II. Percentages of Injury Causes Among Colorado Dairy Farms, Cattle/Livestock Raisers, and Cattle Dealers

	Dairy farms		Cattle/livestock raisers		Cattle dealers	
Injury cause	**Injuries**	**%**	**Injuries**	**%**	**Injuries**	**%**
Animals	307	31.1	471	21.7	336	26.6
Burn	21	2.1	30	1.4	23	1.8
Caught	61	6.2	83	3.8	81	6.4
Cumulative trauma	14	1.4	22	1.0	15	1.2
Cut	52	5.3	161	7.4	73	5.8
Fall or slip	139	14.7	389	17.9	199	15.7
Miscellaneous	71	7.2	94	4.3	47	3.7
Other	15	1.5	51	2.4	39	3.0
Strain	127	12.9	436	20.1	173	13.7
Strike	101	10.2	212	9.8	125	4.9
Struck	68	7.4	160	7.3	126	10.0
Vehicle	12	0.6	59	2.7	51	4.0

The average age of livestock-handling injury claimants among dairy farm workers was 32.2 years (range 18–67 years), and the average employment duration at the time of injury claim was 2.4 years (range 0 months to 20.6 years). The majority of livestock-handling claims were made by males (88%), and by employees on farms employing 11 or more workers (87%) (Table IV). Ninety-eight percent of total dairy employment was represented by farms that employed 11 or more full-time equivalents. Workers between 25 and 34 years of age were 29% more likely to report a livestock-handling injury claim than all other injuries, and workers between 45 and 54 years of age were 58% less likely to report a livestock-handling claim than all other injuries. Mantel–Haenszel χ^2 test for trend revealed a statistically significant trend ($P = 0.03$) of fewer livestock-handling injury claims among older workers (Table IV). The average age of livestock-handling claims among cattle/livestock raisers was 36.3 years (range 17–77 years), and the average employment duration at the time of injury claim was 2.5 years (range 0 months to 40.9 years). The majority of livestock-handling injury claims were made by males (80%), and by employees on farms employing 11 or more workers (57%) (Table V). Seventy-nine percent of cattle/livestock raising total employment was represented by farms that employed 11 or more full-time equivalents. Female workers reported 44% more livestock-handling injury claims than all other injury causes. Workers between 25 and 34 years of age were 29% more likely to report a livestock-handling injury claim than all other injuries, and workers between 55 and 64 years of age were 45% less likely to report a livestock-handling claim than all other injuries. Mantel–Haenszel χ^2 test for trend revealed a statistically significant trend ($P = 0.04$) of fewer livestock-handling injury claims among older workers (Table V). The average age of livestock-handling injury claims among cattle dealers was 38.6 years (range 16–78 years), and the average employment duration at the time of injury claim was 3.4 years (range 0 months to 61.9 years). The majority of livestock-handling claims were made by males (92%), and by employees on farms employing 11 or more employees (67%) (Table VI). Ninety-six percent of cattle dealer total employment was represented by farms that employed 11 or more full-time equivalents. Workers employed by small operations reported 39% more livestock-handling claims than all other injury causes. Mantel–Haenszel χ^2 test for trend revealed a statistically significant trend ($P = 0.10$) of fewer livestock-handling injury claims among older workers (Table VI).

TABLE III. Characteristics of Livestock-Handling Injuries Among Colorado Dairy Farms, Cattle/Livestock Raisers, and Cattle Dealers

	Dairy farms		Cattle/livestock raisers		Cattle dealers	
Characteristic	**Injuries**	**%**	**Injuries**	**%**	**Injuries**	**%**
Nature of injury						
Bruises, contusions	214	69.7	184	39.1	193	57.4
Sprains, strains	25	8.1	54	11.5	44	13.1
Cuts, lacerations	17	5.5	17	3.6	20	5.9
Fractures	10	3.3	67	14.2	25	7.4
Crushing	9	2.9	8	1.7	11	3.3
Puncture	5	1.6	27	5.7	5	1.5
Other[a] or unspecified	27	8.8	114	24.2	38	11.3
Part of body injured						
Head/trunk						
Head[b]	7	2.3	17	1.5	10	2.1
Face[c]	32	10.4	37	6.8	28	9.5
Chest	34	11.1	30	7.2	28	10.1
Abdomen	5	1.6	8	1.1	12	1.5
Internal organs	1	0.3	4	0.2	3	0.3
Neck[d]	1	0.3	7	0.2	1	0.3
Upper back	2	0.7	4	0.4	1	0.6
Low back	13	4.2	26	2.8	25	3.9
Upper extremity						
Shoulders	15	4.9	23	3.2	15	4.5
Upper arm	6	2.0	13	1.3	6	1.8
Elbow	4	1.3	6	0.8	5	1.2
Lower arm	30	9.8	11	6.4	9	8.9
Wrist, hand, fingers	82	26.7	70	17.4	45	24.4
Lower extremity						
Hip	3	1.0	8	0.6	6	0.9
Upper leg	11	3.6	17	2.3	7	3.3
Knees	18	5.9	38	3.8	44	5.4
Lower leg	14	4.6	14	3.0	35	4.2
Ankle, foot, toes	25	8.1	62	5.3	34	7.4
Multiple body parts	1	0.3	10	0.2	4	0.3
Other[a] or unspecified	3	1.0	66	0.6	18	0.9

[a]All remaining categories, each of which accounted for fewer than 7% of injuries.
[b]Includes skull, brain, and multiple head injury.
[c]Includes ears, eyes, facial bones, mouth, nose, facial soft tissue, and teeth.
[d]Includes vertebrae, soft tissue, and multiple neck injury.

Claim Cost and Severity

Costs and severity of livestock-handling injuries are presented in Table VII. One measure of injury severity is if the injury claim involved paid lost time (indemnity). Approximately 85% of dairy farm injury claims involved medical expenses only, while 71% and 75% of injury claims involved medical expenses only among cattle/livestock raisers and cattle dealers, respectively. Cattle/livestock raisers had the highest median paid days off work, followed by cattle dealers and dairy farm workers. On a per claim basis median medical and indemnity costs per injury were lowest for dairy farm workers, and highest for cattle/livestock raisers. Median total (medical plus indemnity) cost per injury was lowest for dairy farm workers, and highest for cattle/livestock raisers.

Injuries were stratified by total cost (<$5,000 vs. ≥$5,000) and injury cause (Table VIII). Among all injury causes that were classified as high cost (≥$5,000), livestock-handling injuries represented the highest proportion in all

TABLE IV. Proportionate Injury Ratio (PIR) Analyses of Livestock-Handling Injuries Among Dairy Farms Comparing Livestock-Handling Injuries to All Other Injuries by Operation Size, Gender, Age, and Experience

	Livestock-handling injuries (%)	All other injuries (%)	Expected livestock-handling injuries[a]	PIR[b] (95% CI)
Operation size				
Large	268 (30.5)	610 (69.5)	275	0.97 (0.86–1.10)
Small	39 (35.5)	71 (64.5)	32	1.22 (0.87–1.67)
Gender				
Female	37 (32.2)	78 (67.8)	35	1.05 (0.74–1.45)
Male	270 (31.0)	602 (69.0)	272	0.99 (0.88–1.12)
Age**				
16–24	80 (30.8)	180 (69.2)	81	0.99 (0.78–1.23)
25–34	128 (36.8)	220 (63.2)	99	1.29 (1.08–1.53)*
35–44	70 (29.4)	168 (70.6)	76	0.92 (0.72–1.17)
45–54	15 (15.8)	80 (84.2)	36	0.42 (0.23–0.69)*
55–64	12 (29.3)	29 (70.7)	13	0.92 (0.47–1.60)
65–79	2 (33.3)	4 (66.7)	2	1.11 (0.12–4.00)
Experience				
0–6 months	134 (30.6)	304 (69.4)	136	0.98 (0.82–1.16)
7 months–2 years	76 (30.9)	170 (69.1)	76	1.00 (0.79–1.25)
2–5 years	61 (35.3)	112 (64.7)	50	1.21 (0.93–1.56)
5+ years	35 (26.7)	96 (73.3)	43	0.81 (0.57–1.13)
Total	307 (31.1)	681 (68.9)		

[a]Expected frequency for livestock-handling injuries by category if they had the same distribution by category as those for all other injuries.
[b]The proportionate injury ratio (PIR) is calculated by dividing the observed livestock-handling injuries by expected livestock-handling injuries within a category.
*Statistically significant (P-value < 0.05).
**Statistically significant Mantel–Haenszel χ^2 test for trend (P-value < 0.05).

three sectors. Nearly 30% of dairy farm high cost injuries were livestock-handling related, while 23.7% and 27.3% injury claims were related to livestock-handling among cattle/livestock raisers and cattle dealers, respectively. Injuries were also stratified by severity (<28 days of paid disability vs. ≥28 days of paid disability), and injury cause (Table IX). Livestock-handling injuries represented the highest percentage of high severity injury claims in all three sectors. Nearly 36% of all high severity (≥28 days of paid disability) injury claims involved livestock handling among dairy farm workers, while 29.1% and 30.2% of high severity injury claims were livestock handling among cattle/livestock raisers and cattle dealers, respectively.

Contributing Factors

Narrative injury event descriptions were analyzed to further elucidate additional factors contributing to livestock-handling injuries. The agent–host–environment model was used to classify the contributing factors. Of the 307 total livestock-handling injury claims among dairy farm workers, all event descriptions contained at least one identifiable factor. On average, event descriptions contained 3.2 contributing factors. Forty-eight percent of livestock-handling claims involved a milking task. More specifically, 21.2% of claims involved the worker being kicked while performing a milking task and 10.1% of claims involved the claimant being kicked while attaching a milking unit. In addition, 8.1% of claims involved the worker being stepped on while performing a milking task (Table X).

All 471 livestock-handling narrative descriptions for cattle/livestock raisers contained at least one contributing factor. On average, event descriptions contained 3.5 contributing factors. Thirty-eight percent of claims involved the worker riding a horse. Numerous work tasks were identified at the time of injury such as branding, ear tagging, horse training, calf birthing, hoof trimming, and vaccinating. More than 50% of descriptions mentioned a horse being responsible for worker injury. Nearly 20% of descriptions indicated the worker was injured when he/she was bucked or thrown off a horse, and 15% of descriptions mentioned the worker was injured when the horse they were riding fell (Table XI).

TABLE V. Proportionate Injury Ratio (PIR) Analyses of Livestock-Handling Injuries Among Cattle/Livestock Raisers Comparing Livestock-Handling Injuries to All Other Injuries by Operation Size, Gender, Age, and Experience

	Livestock-handling injuries (%)	All other injuries (%)	Expected livestock-handling injuries[a]	PIR[b] (95% CI)
Operation Size				
Large	202 (20.2)	799 (79.8)	222	0.91 (0.79–1.05)
Small	269 (23.1)	898 (76.9)	249	1.08 (0.95–1.22)
Gender				
Female	92 (28.6)	230 (71.4)	64	1.44 (1.16–1.77)*
Male	379 (20.5)	1,467 (79.5)	407	0.93 (0.84–1.03)
Age**				
16–24	117 (21.8)	419 (78.2)	116	1.01 (0.83–1.21)
25–34	129 (26.4)	360 (73.6)	100	1.29 (1.08–1.53)*
35–44	97 (19.3)	406 (80.7)	113	0.86 (0.70–1.05)
45–54	97 (23.3)	320 (76.7)	89	1.09 (0.89–1.33)
55–64	24 (13.3)	156 (86.7)	43	0.55 (0.36–0.82)*
65–79	7 (16.3)	36 (83.7)	10	0.70 (0.28–1.44)
Experience				
0–6 months	257 (18.9)	1,106 (81.1)	240	1.07 (0.94–1.21)
6 months–2 years	86 (17.6)	402 (82.4)	87	0.98 (0.79–1.22)
2–5 years	54 (16.0)	283 (84.0)	61	0.88 (0.66–1.15)
5+ years	74 (16.4)	377 (83.6)	82	0.90 (0.71–1.13)
Total	471 (17.8)	1,697 (64.3)		

[a]Expected frequency for livestock-handling injuries by category if they had the same distribution by category as those for all other injuries.
[b]The proportionate injury ratio (PIR) is calculated by dividing the observed livestock-handling injuries by expected livestock-handling injuries within a category.
*Statisticallly significant (P-value < 0.05).
**Statistically significant Mantel–Haenszel χ^2 test for trend (P-value < 0.05).

At least one factor was identified in all 336 livestock-handling event descriptions among cattle dealers. On average, event descriptions contained 3.4 contributing factors. Twenty-seven percent of claims involved horseback riding. Twelve percent of claims involved sorting/pinning cattle while on horseback. Nearly 12% of claims involved the worker being bucked or thrown off a horse. Pushing cattle, vaccinating, loading cattle into a trailer, processing cattle, birthing, and trimming hooves were among the more frequently mentioned job tasks. Nearly 38% of claims indicated a cow or calf was responsible for the worker's injury. Livestock-handling claims indicated various cow actions led to worker injury such as the cow kicked, stepped on, pushed, charged, or had run over the worker. Nearly 17% of claims mentioned a corral gate being involved in the injury event, and 9% of claims involved a cow kicking a gate into the worker. Five percent of claims involved a cow chute. (Table XII).

DISCUSSION

Workers' compensation data have been used for analysis of work-related injuries and illnesses in previous studies [Demers and Rosenstock, 1991; Heyer et al., 1992; Belville et al., 1993; Cooper and Rothstein, 1995; Villarejo, 1998; Douphrate et al., 2006; Hofmann et al., 2006]. Unlike previous studies of WC claims among agricultural workers, the present analysis focused on livestock-handling operations. This focus allowed for the investigation of workplace hazards that were specific to the livestock industry which may differ from the risk factors in other agricultural settings. The present study is the first to utilize WC data to specifically investigate agricultural livestock-handling injuries.

This investigation allowed for the exploration of contributing factors to livestock-handling injuries on specific types of livestock operations. Previous studies have focused on WC claim frequencies in terms of injury cause or type of injury.

The results of this study provided new quantitative evidence that livestock-handling injuries are frequent in the dairy and beef industries, and that these injuries appear to be particularly severe and costly relative to other causes of injury or illness on these operations. The majority of livestock-handling injuries were classified as medical-only

TABLE VI. Proportionate Injury Ratio (PIR) Analyses of Livestock-Handling Injuries Among Cattle Dealers Comparing Livestock-Handling Injuries to All Other Injuries by Operation Size, Gender, Age, and Experience

	Livestock-handling injuries (%)	All other injuries (%)	Expected livestock-handling injuries[a]	PIR[b] (95% CI)
Operation size				
Large	226 (21.4)	830 (78.6)	286	0.93 (0.82–1.05)
Small	70 (33.5)	139 (66.5)	50	1.39 (1.09–1.76)*
Gender				
Female	26 (24.5)	80 (75.5)	29	0.90 (0.59–1.32)
Male	310 (26.7)	849 (73.3)	307	1.01 (0.90–1.13)
Age**				
16–24	62 (30.4)	142 (69.6)	53	1.16 (0.89–1.49)
25–34	93 (30.1)	216 (69.9)	81	1.14 (0.92–1.40)
35–44	67 (23.2)	222 (76.8)	84	0.80 (0.62–1.02)
45–54	81 (29.7)	192 (70.3)	72	1.12 (0.89–1.39)
55–64	26 (21.0)	98 (79.0)	37	0.71 (0.46–1.03)
65–79	7 (23.3)	23 (76.7)	9	0.81 (0.32–1.67)
Experience				
0–6 months	134 (27.6)	351 (72.4)	127	1.06 (0.88–1.25)
6 months–2 years	82 (27.9)	212 (72.1)	77	1.07 (0.85–1.33)
2–5 years	51 (25.9)	146 (74.1)	53	0.97 (0.72–1.27)
5+ years	69 (23.9)	220 (76.1)	80	0.87 (0.67–1.10)
Total	336 (26.6)	929 (73.4)		

[a]Expected frequency for livestock-handling injuries by category if they had the same distribution by category as those for all other injuries.
[b]The proportionate injury ratio (PIR) is calculated by dividing the observed livestock-handling injuries by expected livestock-handling injuries within a category.
*Statisticallly significant (P-value < 0.05).
**Statistically significant Mantel–Haenszel χ^2 test for trend (P-value $= 0.10$).

claims, suggesting most injuries were less severe or did not result in the minimum 3 days of lost work time to qualify for indemnity payments. In addition, the majority of livestock-handling claims in each sector had medical costs less than $5,000. However, in all three sectors, livestock-handling claims accounted for the highest percentage of high-cost and high-severity injuries. Results demonstrated that livestock-handling injuries were the most frequent, severe and costly injuries in terms of total number of claims filed, total workdays missed, and total expenses incurred. On a per-claim basis, livestock-handling injury claims were among the most severe and costly reported injuries in terms of median expenses incurred and lost work time. Our study determined that livestock-handling work injuries were a significant problem, more costly, and resulted in more time off work than other agricultural injury causes on livestock operations.

These data from one state WC provider provide unique descriptive information specific to dairy farms, cattle/livestock raisers, and cattle dealers in the state of Colorado that would not be found in national injury databases. In Colorado, non-fatal work-related injuries and illnesses data are not available because Colorado is one of four states that does not participate in the Bureau of Labor Statistics (BLS) Survey of Occupational Injuries and Illnesses (SOII) [US Department of Labor, 2004]. The present study found annual injury claim incidence rates of 9.4, 8.4, and 10.3 per 100 FTEs for dairy farms, cattle/livestock raisers, and cattle dealers, respectively. These 10-year injury rates are consistent with estimated 5-year injury rates for the same sectors from a previous study [Douphrate et al., 2006]. Injury rates were higher than national estimates among agricultural workers, including 6.4/100 [US Department of Labor, 2004], 7.3/100 [National Safety Council, 2003], and 6.8/100 [Myers, 2001]. Previous studies have reported official data sources underestimate occupational injury rates [Glazner et al., 1998; Van Charante and Mulder, 1998; Cormack et al., 2000], and the BLS Annual Survey is no exception. The BLS acknowledges that many groups are excluded from the survey, including farms with fewer than 11 employees. One government estimate suggests 0.4% of employed persons work on farms with fewer than 10 (not 11) workers [US Department of Labor, 1995]. Pratt et al. [1992] reported roughly 95% of US farms have fewer than 11 employees. The

TABLE VII. Severity and Costs of Livestock-Handling Injuries Among Colorado Dairy Farms, Cattle/Livestock Raisers, and Cattle Dealers

	Dairy farms	Cattle/livestock raisers	Cattle dealers
Total medical-only claims	262	334	251
Total medical plus indemnity claims	45	137	85
Injury severity[a]			
Days of paid disability			
Mean	85	104	164
Median	34	49	41
Range	2–1,082	1–1,338	1–1,103
Duration of paid disability			
0 days	262	137	251
1 to <7 days	9	11	1
7 days to <1 month	12	30	20
1 month or more	24	96	64
Injury costs[b]			
Medical[c]			
Mean	1,711	5,505	6,179
Median	481	607	584
Range	0–33,762	0–403,603	0–348,600
Indemnity			
Mean	8,862	9,697	23,963
Median	2,523	3,499	3,042
Range	0–87,513	0–101,393	0–255,592
Medical plus indemnity total			
Mean	3,360	8,730	13,773
Median	487	717	580
Range	0–132,023	0–427,613	0–382,094

[a]Rounded to nearest whole day.
[b]Rounded to nearest whole US dollar.
[c]Adjusted to 2006 US dollars.

TABLE VIII. Injury Cause Numbers (N) and Proportions (%) by Medical Cost Among Colorado Dairy Farms, Cattle/Livestock Raisers, and Cattle Dealers

	Dairy farms		Cattle/livestock raisers		Cattle dealers	
Injury cause	<$5,000	≥$5,000	<$5,000	≥$5,000	<$5,000	≥$5,000
Animal	278 (31.2)	29 (29.9)	390 (21.4)	81 (23.7)	289 (26.4)	47 (27.3)
Burn	19 (2.1)	2 (2.1)	29 (1.6)	1 (0.3)	22 (2.0)	1 (0.6)
Caught	53 (5.9)	8 (8.2)	76 (4.2)	7 (2.0)	77 (7.0)	4 (2.3)
Cumulative trauma	10 (1.1)	4 (4.1)	18 (1.0)	4 (1.2)	14 (1.3)	1 (0.6)
Cut	46 (5.2)	6 (6.2)	155 (8.5)	6 (1.8)	64 (5.9)	9 (5.2)
Fall or slip	124 (13.9)	15 (15.5)	309 (16.9)	80 (23.4)	156 (14.3)	43 (25.0)
Miscellaneous	67 (7.5)	4 (4.1)	87 (4.8)	7 (2.0)	46 (4.2)	1 (0.6)
Other	14 (1.6)	1 (1.0)	33 (1.8)	18 (5.3)	37 (3.4)	2 (1.2)
Strain	111 (12.5)	16 (16.5)	363 (19.9)	73 (21.3)	145 (13.3)	28 (16.3)
Strike	96 (10.8)	5 (5.2)	180 (9.9)	32 (9.4)	113 (10.3)	12 (7.0)
Struck	64 (7.2)	4 (4.1)	141 (7.7)	19 (5.6)	110 (10.1)	16 (9.3)
Vehicle	9 (1.0)	3 (3.1)	45 (2.5)	14 (4.1)	20 (1.8)	8 (4.7)
Total	891 (100.0)	97 (100.0)	1,826 (100.0)	342 (100.0)	1,093 (110.0)	172 (100.0)

TABLE IX. Injury Cause Numbers (N) and Proportions (%) by Injury Severity Among Colorado Dairy Farms, Cattle/Livestock Raisers, and Cattle Dealers

	Dairy farms		Cattle/livestock raisers		Cattle dealers	
Injury cause	**High**	**Low**	**High**	**Low**	**High**	**Low**
Animal	31 (35.6)	276 (30.6)	95 (29.1)	376 (20.4)	38 (30.2)	298 (26.2)
Burn	2 (2.2)	19 (2.1)	1 (0.3)	29 (1.6)	1 (0.8)	22 (1.9)
Caught	5 (5.7)	56 (6.2)	9 (2.8)	74 (4.0)	3 (2.4)	78 (6.8)
Cumulative trauma	2 (2.2)	12 (1.3)	3 (0.9)	19 (1.0)	0 (0.0)	15 (1.3)
Cut	3 (3.4)	49 (5.4)	8 (2.4)	153 (8.3)	1 (0.8)	72 (6.3)
Fall or slip	14 (16.1)	125 (13.9)	72 (22.0)	317 (17.2)	31 (24.6)	168 (14.7)
Miscellaneous	2 (2.2)	69 (7.7)	4 (1.2)	90 (4.9)	0 (0.0)	47 (4.1)
Other	1 (1.1)	14 (1.6)	14 (4.3)	37 (2.0)	0 (0.0)	39 (3.4)
Strain	14 (16.1)	113 (12.5)	67 (20.5)	369 (20.0)	21 (16.7)	152 (13.3)
Strike	3 (3.4)	98 (10.9)	24 (7.3)	188 (10.2)	12 (9.5)	113 (9.9)
Struck	7 (8.0)	61 (6.8)	15 (4.6)	145 (7.98)	14 (11.1)	112 (9.8)
Vehicle	3 (3.4)	9 (1.0)	15 (4.6)	44 (2.4)	5 (4.0)	23 (2.0)
Total	87 (100.0)	901 (100.0)	277 (100.0)	1,891 (100.0)	126 (110.0)	1,139 (100.0)

present study was able to include operations employing a minimum of one worker since these operations are required to maintain WC coverage in Colorado.

Among dairy farm workers, the majority of livestock-handling injuries involved large operations (more than 10 workers), male workers, younger workers, and less experienced workers. Being kicked, stepped on, or pushed by the cow were the three most frequent animal actions that led to worker injury. Most injury body locations were above the waist level of the dairy worker. Nearly 27% of injuries were to the wrist, hand, and fingers, nearly 13% to the head or face, and 11% to the chest. These results indicate the vulnerability of these body parts to injury due to the worker-livestock interface. Analysis of event descriptions confirms this finding and clearly identifies working in close proximity to the hind quarters of a cow while milking is a task in need of safety intervention. Nearly 50% of livestock-handling injury claims mentioned the injury took place in the dairy parlor while performing a milking task. Boyle et al. [1997] investigated specific tasks associated with dairy operations and found milking to have the greatest increased risk for injury. Hoskin and Miller [1979] found milking was the ‘‘victim activity’’ in the greatest number of cases of animal-related injuries. Pinzke et al. [2001] quantified the physical workload on the upper extremity for fundamental work tasks during machine milking. High muscle loads in combination with extreme positions and movements of the hand and forearm may also contribute to the development of injuries among parlor workers. The increased workload on the upper extremity due to high repetitions associated with large milking herds, in conjunction with being vulnerable to being kicked or stepped on by a cow, places parlor workers at higher risk for injury.

Among cattle/livestock workers, the majority of livestock-handling injury claims were made by males, and workers on farms employing 11 or more employees. Female cattle/livestock workers reported 44% more livestock-handling injury claims than all other injury causes. The highest percentage of livestock-handling injuries involved horseback riding among both cattle/livestock raisers and cattle dealers. Penning/sorting cattle while on horseback represented a large percentage of livestock-handling injury claims. Horses were responsible for a majority of worker injuries in both of these sectors, accounting for a larger proportion than cattle. While the use of ATVs on farms appears to be growing [Goldcamp et al., 2006], injury claim patterns indicate that horseback riding continues to be common when performing livestock-handling tasks.

Study Limitations

The data utilized in this study were collected and maintained for industrial insurance purposes rather than for epidemiological research. As a result, claims data may not be representative of all injuries sustained on livestock operations. Any work-related injuries not reported would have been missed in this study, and these results likely underestimate the true burden of injuries among dairy farm, cattle dealer, and cattle/livestock workers. WC data are susceptible to an underreporting of injury claims, especially in agriculture. Studies suggested the percentage of injured workers who qualify for WC but never file a WC claim ranges from 35% to 79% [Biddle et al., 1998; Morse et al., 1998; Rosenman et al., 2000; Shannon and Lowe, 2002]. Previous studies have shown musculoskeletal disorders are generally underreported, and WC data do not accurately reflect

TABLE X. Contributing Factors of 307 Livestock-Handling Injuries Among Dairy Farm Workers as Identified Injury Claim Event Descriptions

	N	%
Host (worker)		
Job activity		
Milking	147	47.9
Kicked while milking	65	21.2
Kicked while attaching milking unit	31	10.1
Kicked while stripping cow	8	2.6
Stepped on while milking	25	8.1
Stepped on while attaching milking unit	16	5.2
Hit by tail while milking	2	0.7
Bringing cows to parlor		
Pushing cows in parlor line	43	14.0
Herding cows to milk	16	5.2
Other activities		
Walking/standing behind cow (non milking)	13	4.2
Calf pulling	7	2.3
Pregnancy check	5	1.6
Inseminating	5	1.6
Administering IV/shot	4	1.3
Restraining cow	3	1.0
Castrating	2	0.7
Feeding cattle/calves	2	0.7
Marking cow	2	0.7
Chasing cow	1	0.3
Palpating cow	1	0.3
Pulling calf out of mud	1	0.3
Locking up cow	1	0.3
Slipped and fell	1	0.3
Removing stitches	1	0.3
Agent (animal)		
Animal action		
Cow kick	126	41.0
Cow stepped on	43	14.0
Cow pushed	31	10.1
Swung head around	11	3.6
Cow pinned	10	3.3
Bull charged	5	1.6
Cow flipped/fell	4	1.3
Another cow	2	0.7
Swung tail	2	0.7
Calf	8	2.6
Environment		
Location		
In dairy parlor	147	47.9
In parlor feeder pen	39	12.7
In cattle/calf pen	11	3.6
Equipment		
Milking unit	47	15.3
Milking rail	16	5.2
Corral gate	13	4.2
Fencing	9	2.9
Wall	8	2.6
Squeeze chute	5	1.6
Herdlock	2	0.7
Calf feeder	1	0.3
Hose	1	0.3

prevailing musculoskeletal occurrence rates [Lipscomb et al., 1997; Biddle et al., 1998; Morse et al., 1998; Herbert et al., 1999; Pransky et al., 1999; Rosenman et al., 2000; Morse et al., 2005]. By industry, agriculture/forestry/fishing and construction rank higher in reporting work-related injury or illness and lower WC claim filing. By occupation, farming/forestry/fishing ranks highest in reporting work-related injury or illness and second lowest in WC claim filing [Fan et al., 2006]. Osorio et al. [1998] reported evidence of underreporting among California farm workers. In addition, injury reporting is vulnerable to a variety of filtering effects which may have an influence on WC claim reporting [Webb et al., 1989]. Employer and location variations in WC reporting and recording practices may also limit the results [Smith et al., 2005]. The present study was restricted to compensable claims in one state, which may limit the influence of reporting variation due to differing state WC claim filing rules and procedures.

In this study, the injury claim rate was a measure of incidence with claims as the numerator and hours of work as the denominator. An underreporting of injury claims would result in an underestimation of injury claim rates. Payroll data were used to estimate work hours of exposure, and likely resulted in an underestimation of livestock-handling injury rates. Injury rate estimation is dependent on work hours of exposure in relation to differential risk of work-related injuries [Stallones and Beseler, 2003]. More accurate assessment of exposure work hours specific to livestock handling would have resulted in more accurate livestock-handling injury rates. Future agricultural injury research should incorporate more accurate assessment of exposure work hours in relation to specific agricultural tasks.

The degree to which results from Colorado agricultural workers and operations apply to other states or jurisdictions is unknown, and should be approached with caution. While Colorado WC insurance follows the NCCI standards for class codes, a number of states with very large numbers of hired workers do not use NCCI standards (e.g., CA, NJ, NY, PA, WA). Care must also be taken when using class codes for comparative purposes. In addition, the exclusion of employers who maintained WC coverage with another carrier or who elected to self-insure limits our ability to generalize these

TABLE XI. Contributing Factors of 471 Livestock-Handling Injuries Among Cattle/Livestock Raisers as Identified Injury Claim Event Descriptions

	N	%
Host (worker)		
Job activity		
Riding horseback	177	37.6
Sorting cattle while riding horse	30	6.4
Pushing cattle while standing	13	2.8
Branding	10	2.1
Ear tagging	9	1.9
Castrating	3	0.6
Calf pulling	5	1.1
Trimming hoof	5	1.1
Vaccinating	5	1.1
Training horse	10	2.1
Mounting horse	6	1.3
Loading cattle trailer	5	1.1
Saddling horse	4	0.8
Roping calf	4	0.8
Pregnancy check	2	0.4
Wrapping horse leg	3	0.6
Washing horse	2	0.4
Feeding horse	1	0.2
Inseminating horse	2	0.4
Lifting calf	2	0.4
Haltering horse	1	0.2
Agent (animal)		
Cow		
Cow kick	35	7.4
Cow stepped on	7	1.5
Cow pushed	2	0.4
Cow swung head	5	1.1
Cow run over	16	3.4
Cow/bull charged	5	1.1
Cow kicked gate	11	2.3
Calf		
Calf kick	19	4.0
Horse		
Horse bucked/threw rider off	92	19.5
Horse fell while being ridden	69	14.6
Horse stepped on	22	4.7
Horse kick	34	7.2
Horse knocked over by animal	6	1.3
Horse pushed	11	2.3
Horse whipped tail	3	0.6
Horse bite	2	0.4
Buffalo		
Buffalo kick	3	0.6
Environment		
Location		
In corral with cattle/horses	4	0.8
Between horses	2	0.4
Behind cow	5	1.1
In horse stall	5	1.1
In trailer	3	0.6
Equipment		
Gate kicked into worker	11	2.3
Squeeze chute	2	0.4
Corral gate	6	1.3
Fencing	3	0.6
Horse riding terrain		
Hole	19	4.0
Stream	2	0.4
Steep	3	0.6
Slippery	3	0.6
Mud	3	0.6

results to all Colorado dairy farms, cattle dealers, and cattle/livestock raisers.

Study limitations also include factors related to methods and systematic features of WC data analysis. Claims data used in the present study were restricted to hired farm workers in one state, and may exclude farm owners. In Colorado, business owners may elect to decline WC coverage for themselves. In addition, small farm operations without hired workers may not be represented in the dataset.

The completeness and accuracy of the data were a concern for some variables and the possibility of misclassification of claims could not be ruled out. Due to restrictions in access to the primary First Report of Injury claim documents for the purposes of claimant confidentiality, we were unable to review these documents and assess the impact of misclassification. Zakaria et al. [2003] assessed the accuracy of WC claims coding and found an overall accuracy of 86% with respect to nature of injury and part of body injured classifications.

Indemnity cost data in the present study did not take into account disability from those workers who did not lose enough time from work to satisfy state waiting periods for wage replacement benefits (3 days in Colorado). Thus, our results likely underestimate actual indemnity costs experienced by injured workers. In addition, medical and indemnity costs did not encompass all dimensions of the financial burden of injury. Burden also includes indirect costs such as lost productivity, increased absenteeism, higher employee turnover, and recruitment of replacement workers [Shah et al., 2005].

The agent–host–environment model used in this study did not include organizational factors, and these factors were rarely mentioned in injury event descriptions. It is possible that they played a more important role than described. Event

TABLE XII. Contributing Factors of 336 Animal-Related Injuries Among Cattle Dealers as Identified in Injury Claim Event Descriptions

	N	%
Host (worker)		
Job activity		
Riding horseback	89	26.5
Pinning cattle on horseback	33	9.8
Sorting cattle while riding horse	41	12.2
Pushing cattle while standing	20	6.0
Branding	1	0.3
Ear tagging	5	1.5
Castrating	1	0.3
Calf pulling	5	1.5
Trimming hoof	6	1.8
Vaccinating	12	3.6
Mounting/dismounting horse	3	0.9
Loading cattle in trailer	26	7.7
Roping calf	2	0.6
Inseminating horse/cow	2	0.6
Processing cattle	7	2.1
Feeding/watering cows	4	1.2
Destroying	1	0.3
Agent (animal)		
Cow		
Cow kick	40	11.9
Cow stepped on	10	3.0
Cow pushed		0.0
Cow swung head	20	6.0
Cow run over	23	6.8
Cow/bull charged	17	5.1
Cow kicked gate		0.0
Calf		
Calf kick	13	3.9
Calf pushed	3	0.9
Horse		
Horse bucked/threw rider off	40	11.9
Horse fell while being ridden	4	1.2
Horse stepped on	9	2.7
Horse kick	7	2.1
Horse knocked over by animal	1	0.3
Horse pushed	2	0.6
Horse swung head	4	1.2
Horse bite	1	0.3
Environment		
Location		
In corral with cattle/horses	5	1.5
Behind cow	16	4.8
Processing barn	3	0.9
Pinned between cow & gate	11	3.3
Equipment		
Gate kicked into worker	29	8.6
Squeeze chute	17	5.0
Corral gate	27	8.0
Fencing	5	1.5
Horse riding terrain		
Hole	38	11.3
Weather		
Cold/snow	7	2.1

descriptions were likely to focus on the immediate situation in which the injury occurred, and neglect mentioning other factors which may have contributed to the injury. Organizational factors such as adequacy of safety training, corporate safety culture, and workplace safety climate were rarely mentioned in the dataset. Failure to identify all factors contributing to injury is a limitation of injury report analysis [Glazner et al., 2005]. For example, one injury event description included "My boss required me to work and didn't take me to the doctor for a week." Another description included "It took a while for the ambulance to arrive." Organizational factors such as these may influence the level of severity and magnitude of cost associated with each injury.

Limitations were also associated with utilizing proportionate analyses. One limitation is that the sum of proportionate ratios must be equal to one. Therefore, the magnitude of a high ratio is offset by relative or corresponding lower magnitude of other ratios, making the ratios of the different injury categories interdependent. However, proportionate analyses (e.g., proportionate mortality ratio or PMR) which are similar to the PIR have proven to be useful as indicators of risk [Lipscomb and Li, 2001; Checkoway et al., 2004; Lombardi et al., 2005], and provided important new information in our study.

CONCLUSIONS

The present study complements previous studies specific to agricultural injury, and adds insight into the contributing factors of livestock-handling injuries. The present study demonstrated the application of the agent–host–environment epidemiological model to the analysis of WC data. Nearly 50% of dairy farm livestock-handling injuries took place in the milking parlor. More focused research should investigate milking practices and parlor designs as they relate to worker safety and health. Additional dairy-related injury research is vital given the trend toward large industrial milking operations. Large-herd and "mega-herd" dairy operations will present new and challenging opportunities for developing effective safety interventions. Among cattle/livestock raisers and cattle dealers, livestock-handling injury prevention efforts should be directed at livestock-handling facility and equipment design. Livestock equipment and facilities should be designed to minimize worker-livestock interactions. All workers in agriculture who handle livestock should be knowledgeable of livestock-behavior and proper handling techniques. The present study determined that livestock-handling work injuries are a significant problem, more costly, and result in more time off work than other agricultural injury causes. Increased attention should be focused on livestock-handling injuries via continued research and safety intervention development.

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